

Contribution to the Knowledge of the Chinese Terrestrial Malacofauna (Gastropoda: Pulmonata: Helicoidea): Description of a New Bradybaenid Genus with Three Species

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Abstract. *Trichobradyaena*, gen. nov. (Gastropoda, Stylommatophora, Bradybaenidae) with three species, characterized by the association of a simple penial caecum on the penis near the penis-epiphallus transition and two mucus glands inserted on the dart sac, is described from the region of Yangtze River, China. Shell morphology and genitalia of all three species are described and figured. A distribution map and keys both to Chinese bradybaenid genera and to *Trichobradyaena* species are also provided. The morphology of the gonad gland, which shows consistent interspecific difference in *Trichobradyaena*, gen. nov., is here used for bradybaenid classification for the first time. The three members of the genus are *T. chagangensis*, sp. nov., *T. tuberculata*, sp. nov., and *T. submissa* (Deshayes, 1873) comb. nov.; the latter is designated type species. *Trichobradyaena submissa* is widespread in several mid-western provinces of China. The other two species are both narrowly distributed on the eastern slope of the Qinghai-Tibet Plateau and only known from the type material. All type specimens involved are deposited at the Museum of the Institute of Zoology, Chinese Academy of Sciences.

INTRODUCTION

Müller described the first bradybaenid species, *Bradybaena fruticum*, in 1774. Since then, more than 150 malacologists have worked on the taxonomy of this group (Richardson, 1983, and numerous citations therein). Heude (1882, 1885, 1890) examined 78 species of Chinese bradybaenids and grouped them in *Helix* Linnaeus, 1758. His publication is still the only work with the localities both in a foreign language and in Chinese. Möllendorff (1899) described 129 species and subspecies including 72 new species and subspecies belonging to 15 genera, of which two genera established by him are still regarded as valid. Wiegmann (1900) worked on the genital anatomy of this group and tried to find some new evidence for its classification. He published on 31 species grouped into 11 genera and subgenera on the basis of shell and anatomy. The milestone of bradybaenid study was by G. W. Tryon, Jr. and Henry A. Pilsbry; their "Manual of Conchology" includes a total of 201 bradybaenid species, most of which are well illustrated and, in some cases, the anatomy is also presented. Pilsbry (1934) proposed the subfamily Bradybaeninae for them many years later. Yen (1939) ("Yan" in today's

spelling) examined the fine sculpture of the embryonic shell of Chinese bradybaenid snails. Neglecting all the anatomical information of the earlier authors, Yen (1939) catalogued the Chinese bradybaenid snails deposited in the Senckenberg Museum and arranged the 182 species he recognized in 18 genera.

The taxonomy of the Bradybaenidae is far from stable, however. "Möllendorff had once indicated such instability by an example that when two famous malacologists prepared the catalogues of 240 bradybaenid snails, only 87 species were arranged in the same genera" (Richardson, 1983). Although some authors worked on the systematic arrangement of this group (Thiele, 1931; Zilch, 1960; and others), the systematic framework of bradybaenids unfortunately remains for various reasons an artificial one, in comparison with the much more intensive work conducted in many other helicoid groups. Two main factors contribute to this situation: 1. Almost all morphological study focused on the shell features instead of anatomy, especially that of the reproductive system, which would provide more reliable characters varying less under different ecological conditions 2. Very few malacologists have carried out studies on this group on the mainland of

China since 1950, although many specimens were collected after that time.

In China, the mid-western area, especially the area adjacent to the region along the eastern slope of Qinghai-Tibet Plateau, has a diverse terrestrial mollusk fauna (Möllendorff, 1899; Pilsbry, 1934). About one-third of the known Chinese bradybaenids, including numerous endemic species, inhabit this area. This study presents a partial result of a malaco-faunistic survey in the southern part in Gansu province and adjacent northern Sichuan and a partial result of the study on the collections accumulated in the Zoological Museum of the Institute of the Zoology (ZMIZ), the Chinese Academy of Sciences (CAS).

There are many terminological systems used by various malacologists when working on the genital anatomy of helicoid snails (Thiele, 1931; Schileyko, 1978; Azuma, 1982; Wu, 1982; Miller, 1984; Nordsieck, 1987; Aparicio & Ramos, 1988; Picoral & Thomé, 1989; Aparicio et al., 1991; Solem, 1992; Wu, 2001; and others). In the present work, the terms used mainly refer to those by the above authors. However, considering different terms used by different authors, here the abbreviations of the used terms and their corresponding explanations are given as follows (terms newly used in the present paper are labeled with an asterisk): ADC*—accessory sac-dart sac chamber; AG—albumen gland; AS—accessory sac; At—atrium; C23*—chamber produced by V2 and V3, in dart sac; DC—dart sac chamber; DS—dart sac; Dt—amatorial dart; DtC*—a chamber in which the amatorial dart is actually contained; DVM*—membranous sac surrounding dart sac and proximal region of vagina, beyond atrium; MAC*—mucus gland-accessory sac channel; MG—mucus glands; P—penis; PR—penial retractor muscle; PS—penial sheath; PP—penis pilaster; S—spermatheca; SD—spermathecal duct; SPC*—simple penial caecum near the penis-epiphallus transition; T—talon; Va—vagina; VD—vas deferens; V1*—a valvule opposite the entrance of mucus glands, in sagittal plane of dart sac; V2*—a valvule opposite V1 and closest to atrium, in sagittal plane of dart sac; V3*—a valvule between V2 and V4, in sagittal plane of dart sac; V4*—most inner/distal valvule in DC, along with V1 forming a chamber containing amatorial dart, in sagittal plane of dart sac. In the description of genitalia, the adjectives “proximal” and “distal” are used to indicate the direction toward the atrium and the reverse direction, respectively. Shell and genital measurements were taken with 0.01 mm and 0.1 mm accuracy, respectively. Whorls are counted as described by Kerney & Cameron (1979). Coloration and length of soft parts in the descriptions refer to those observed and measured after preservation in 70% ethanol. All specimens examined, including types, are preserved in 70% ethanol and deposited in ZMIZ, CAS, Beijing.

Key to the Chinese Genera of Bradybaenidae, with Distribution in China Indicated¹

- 1a Flagellum present or absent. Dart sac containing one amatorial dart 2
- 1b Flagellum present. Dart sac containing two amatorial darts ... *Nesiohelix* Kuroda & Emura, 1943
Distribution: Zhejiang, Hunan, Guangxi
- 2a Flagellum present 3
- 2b Flagellum absent 7
- 3a Penial caecum present and with complicated inner folds 4
- 3b Penial caecum absent 5
- 4a Mucus glands with numerous ducts
..... Genus A (to be described elsewhere)
Distribution: Yunnan
- 4b Mucus glands with two ducts
..... Genus B (to be described elsewhere)
Distribution: Sichuan
- 5a Mucus glands with numerous ducts
..... *Euhadra* Pilsbry, 1890
Distribution: See explanation following
- 5b Mucus glands with two ducts 6
- 6a Body whorl strongly keeled. Periostracum scaly or hairy *Plectotropis* Martens, 1860
Distribution: All provinces except Tibet, Xinjiang, Interior Mongolia (Neimenggu), Heilongjiang, Jilin & Liaoning
- 6b Body whorl unkeeled. Periostracum usually smooth *Aegista* Albers, 1850
Distribution: Anhui, Guangdong, Guizhou, Hubei, Hunan, Jiangsu, Jiangxi, Zhejiang, Sichuan, Taiwan, Yunnan
- 7a Simple penial caecum occurring on penis near the penis-epiphallus transition 8
- 7b No penial caecum occurring on penis near the penis-epiphallus transition 9
- 8a Mucus glands with two ducts. Periostracum hairy or scaly *Trichobradyaena*, gen. nov.
Distribution: Anhui, Gansu, Shaanxi, Sichuan (Figure 1)
- 8b Mucus glands with numerous ducts. Periostracum smooth *Mastigeulota* Pilsbry, 1895
Distribution: Valley of Yangtze River, Zhejiang
- 9a Shell dull; of various shapes 10
- 9b Shell extremely shiny; disc-shaped
..... *Stilpnodiscus* Möllendorff, 1899
Distribution: S Gansu, N Sichuan
- 10a Mucus glands with two ducts, or numerous ducts arranged into a transverse series inserting into accessory sac 11

¹ *Coccolypta* Pilsbry 1895, and *Armandiella* Ancy 1901, are absent from this key because no anatomic information is available for them.

- 10b Mucus glands with a bundle of more than two ducts 15
- 11a Shell turreted or highly conical. Accessory sac extremely reduced
..... *Pseudobuliminus* Gredler, 1886
Distribution: Anhui, Gansu, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Sichuan, Taiwan, Yunnan
- 11b Shell globose or flattened. Accessory sac more or less developed 12
- 12a Mucus glands with two branches, or arranged in a transverse series inserting into accessory sac. Accessory sac free 13
- 12b Mucus glands with two branches. Accessory sac more or less incorporated in the dart sac
..... *Bradybaena* Beck, 1937
Distribution: Subtropical regions; see explanation following
- 13a Mucus glands with two branches of tubes ... 14
- 13b Mucus glands arranged in transverse series, inserting into accessory sac
..... *Karafkaohelix* Pilsbry, 1927
Distribution: See explanation following
- 14a Accessory sac attached basally beside dart sac
..... *Fruticicola* Held, 1838
Distribution: NW Sichuan, S Gansu; see explanation following
- 14b Accessory sac attached at the center of dart sac
..... *Acusta* Martens, 1860
Distribution: All provinces except Interior Mongolia, Heilongjiang, Liaoning, and Tibet
- 15a Shell always sinistral; umbilicus broad 16
- 15b Shell usually dextral; umbilicus usually quite narrow 17
- 16a Shell more or less carinate. Periostracum smooth or scaly
..... *Laocathaica* Möllendorff, 1899
Distribution: Gansu, Hubei, Shaanxi, Sichuan
- 16b Shell not carinate. Periostracum hairy
..... *Trichocathaica* Gude, 1919
Distribution: Sichuan, Yunnan
- 17a Aperture toothless or with an indistinct lower tubercle 18
- 17b Aperture with one to four strong teeth
..... *Methodontia* Möllendorff, 1886
Distribution: Anhui, Beijing, Gansu, Hebei, Henan, Hubei, Jiangsu, Neimenggu, Qinghai, Shanxi, Shandong, Shaanxi
- 18a Shell strongly carinate at periphery
..... *Pseudiberus* Ancey, 1887
Distribution: Gansu, Hebei, Hubei, Shaanxi, Shandong, Sichuan, Xinjiang, Zhejiang
- 18b Shell not carinate at periphery, at most bluntly angulate peripherally
..... *Cathaica* Möllendorff, 1884

Distribution: Region north of Yangtze River, Yunnan

Several species of *Euhadra* have been recorded from various localities in China, based merely on shell features (Blume, 1925; Crosse, 1864; Gude, 1902; Heude, 1885, 1889; Möllendorff, 1899; Schmacker & Böttger, 1894; Wiegmann, 1900; Yen, 1939). Based on recent study of bradybaenids in China, none of the snails anatomically known has "flagellum + mucus glands with numerous ducts"—the associated characters diagnostic of *Euhadra*. All species classified as *Euhadra* by the classical authors are banded and colored *Bradybaena* or *Fruticicola* species (see Wiegmann, 1900), and those of Yen are *Nesiohelix* species (see Yen, 1939) (H. Nordsieck, personal communication). It might indicate that *Euhadra* does not occur in China. However, in this key this genus is included because so far no solid evidence can demonstrate that *Euhadra* is absent from China, until all Chinese species assigned to *Euhadra* are anatomically examined.

Bradybaena is a subtropical genus and its Chinese species are distributed in the region limited by the Yangtze River in the north. The distribution of *Karafkaohelix* is not indicated in the present key because the only known species possibly occurs in China in the Heilongjiang region (= Chinese Amur region) (Schileyko, 1978). It is uncertain whether *Karafkaohelix weyrichii* (Schrenk, 1867) (a synonym of *Karafkaohelix bocageana* [Crosse, 1864] which is the older name) is a Chinese species (Crosse, 1864; Schileyko, 1978). In this key the genus is still included, however. The known distribution range of real *Fruticicola* species is only S Gansu and NW Sichuan (Wiegmann, 1900). The complete distribution range of this genus and *Bradybaena* will be known only when all members of these genera are known anatomically.

SYSTEMATICS

Family BRADYBAENIDAE Pilsbry, 1934

Trichobradysbaena Wu & Guo, gen. nov.

Type species: *Helix submissa* Deshayes, 1873.

Diagnosis: Shell depressed; dextral; periostracum scaly or hairy; embryonic shell granulose; spiral furrows absent; lips simple; umbilicus broad. Genitalia with a simple penial caecum occurring near the penis-epiphallus transition; flagellum absent; dart sac with one amatorial dart; accessory sac as a vestige or less developed; mucus glands with two ducts.

Shell: Fairly depressed, height 5.92–9.34 mm, diameter 11.80–20.87 mm, ratio of height to diameter 0.38–0.59 mm. Shell dextral, thin to thin but solid. Apex distinct but blunt. Shell with 5½–6½ whorls, embryonic shell with 1½–2¼ whorls, whorls convex. Suture superficial to distinctly impressed, with or without protruding periphery

above suture. Umbilicus broad, 2.70–5.56 mm wide, ratio of umbilicus diameter to shell diameter 0.21–0.36 mm. Columella arched. Columellar lip not distinctly dilated, seldom covering umbilicus. Periostracum of adult and immature shells evenly rough with minute scales or short hairs, shape of hairs differentiated among species; spiral furrows and ribs always absent. Embryonic shell finely granulated. Post-embryonic shell smooth to completely granulated. Immature shells unkeeled to sharply keeled. Body whorl unkeeled to sharply keeled. Body whorl large, not descending to more or less descending in front, base moderately or strongly convex. Aperture rounded, ovate, or roundly rhombic, more or less oblique, 4.73–8.52 mm in length, 4.24–8.13 mm in width. Lips toothless, thin or thickened at base, basally not or minutely expanded within. Peristome thin. Parietal callus transparent and indistinct. Shell dull to slightly shiny, usually semi-transparent, whitish corneous-brown, yellowish brown, or brown. Base of body whorl similarly colored or somewhat paler. Shell band absent.

Soft body color: Background creamy white with several brown spots anteriorly to darkened with spots throughout.

Jaw: Arcuate with six to nine ribs dentating the concave margin. Ribs separate or contiguous.

Genitalia: Atrium short. Penis short and swollen to rather long and slender, with simple penial caecum near the penis-epiphallus transition. Penis (P) with a long or short penis sheath (PS), commencing at base of penis. Structure inside penis with numerous thin and simple penis pilasters (PPs), no other complicated structure. Retractor short to moderately long. Flagellum absent. Beyond atrium (At), dart sac and vagina proximally surrounded by a membranous sac (DVM). Dart sac of moderate size, more or less elongated, containing one amatorial dart. Dart about 2.8–4.0 mm long, straight or slightly curved, proximal part rounded and not expanded. Cross-section of dart not always rounded or ovate, two-bladed at distal part. Ratio of bladed part to the whole dart about 0.50–0.60. Accessory sac as a vestige or less developed. In sagittal section, dart apparatus internally with 1 + 3 valvules, respectively V1—a valvule opposite the entrance of mucus glands, V2—a valvule opposite V1 and closest to atrium, V3—a valvule between V2 and V4, V4—most inner/distal valvule in dart sac chamber, along with V1 forming a chamber containing amatorial dart. V1 closed to dart sac chamber (DtC) or not. Chamber limited by V2 and V3 (C23) more or less deepened, accessory sac-dart sac chamber (ADC) extended distally or not. Mucus glands always with two mucus ducts, with stalks distinct or indistinct. Lobules of mucus glands arranged radially, simply branched to complicated and irregularly arborescent, distally not expanded. Spermatheca oval or of longer shape, well differentiated from its duct. Spermathecal duct of moderate length. Gonad glands palm-shaped and

branched, or racemose. Measurement range of genitalia: dart apparatus 6.7–8.3 mm long, 1.6–2.0 mm wide; mucus duct 4.8–9.8 mm long; vagina 5.7–6.9 mm long; spermatheca duct 7.7–10.7 mm long; spermathecal duct proximal width 0.6–1.3 mm; vas deferens 17.7–23.2 mm long; penis 7.3–27.0 mm long; penial retractor 1.5–4.6 mm long.

Etymology: The genus name is a compound of Greek *tricho-* (= hairy) and *bradybaena* which is an existing bradybaenid genus.

Distribution: Along the valley of Yangtze River; also distributed in the region between the Yellow River and the Yangtze River, Mid-China (Figure 1).

Key to the Species of *Trichobradyaena*, gen. nov.

- 1a Ratio of umbilicus diameter to shell diameter 0.30–0.36 (mean 0.34); penis slender; penial retractor of moderate length; dart proximally not expanded *Trichobradyaena chagangensis*, sp. nov.
- 1b Ratio of umbilicus diameter to shell diameter up to 0.27; penis of moderate thickness or swollen; penial retractor short; dart proximally expanded 2
- 2a Immature shells sharply keeled. Body whorl of mature shell sharply keeled; aperture more or less oblique. Outer lip and basal lip expanded. Accessory sac developed *Trichobradyaena tuberculata*, sp. nov. (Figures 21–29)
- 2b Immature shells unkeeled and unangulated. Body whorl of mature shell unkeeled; aperture oblique; lips seldom expanded. Accessory sac indistinct ... *Trichobradyaena submissa* (Deshayes, 1873), comb. nov. (Figures 11–20)

Trichobradyaena chagangensis Wu & Guo, sp. nov.

(Figures 1–10)

Diagnosis: Suture distinctly impressed. Aperture rounded. Soft body anteriorly with several brown spots. Jaw with six to seven ribs dentating the concave margin. Penis rather long and slender. Retractor of moderate length. V1–V4 closely situated, C23 fairly tiny with entrance leading to mucus channel. Accessory sac indistinct. Amatorial dart about 3 mm long, proximal part not expanded. Mucus glands as long as dart sac. Gonad glands palm-shaped.

Shell (Figures 2–4): Height 6.08–8.45 mm (mean 7.10 mm) diameter 12.54–16.47 mm (mean 14.51 mm) ratio of height to diameter 0.45–0.52 (mean 0.49). Shell thin

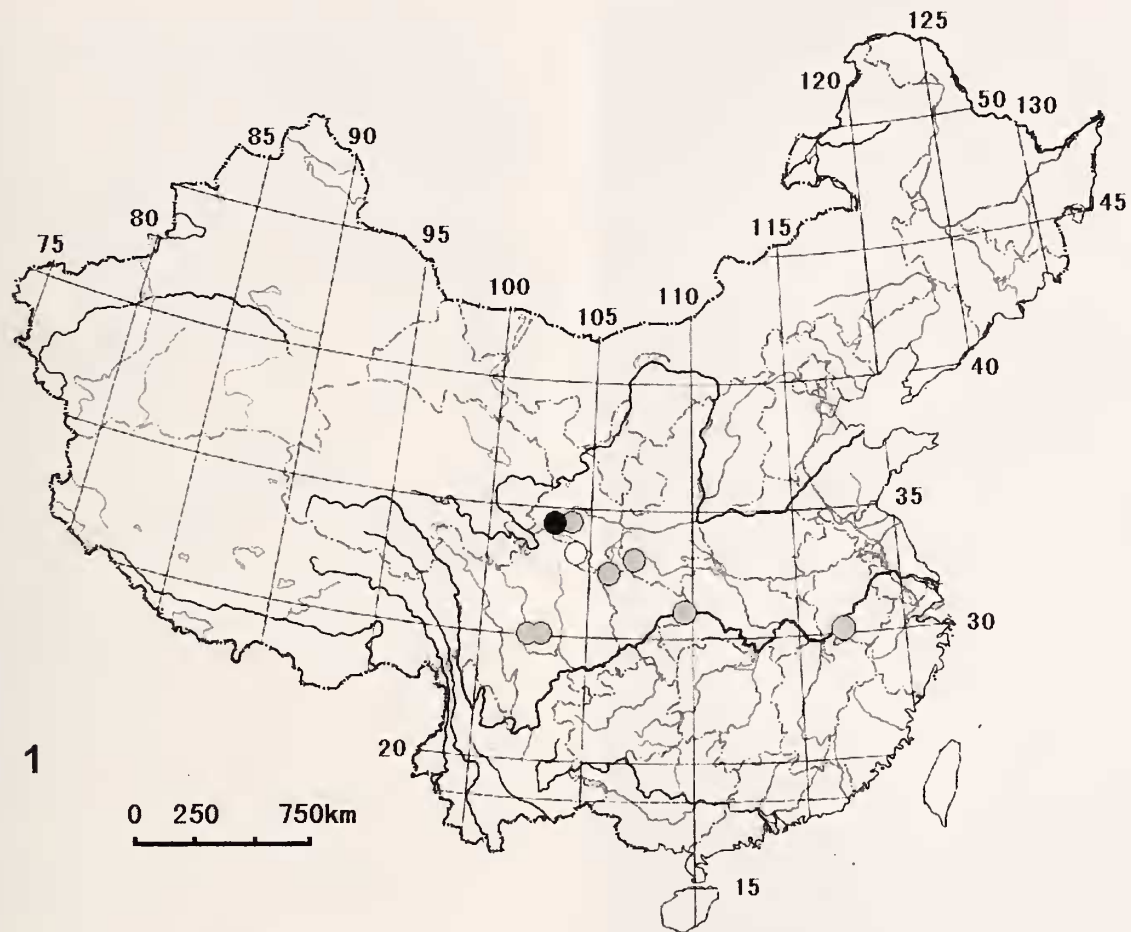


Figure 1. Distribution map of species of *Trichobryadybaena* Wu & Guo, gen. nov. Black dot: *Trichobryadybaena chagangensis* Wu & Guo, sp. nov. Grey dot: *Trichobryadybaena submissa*, comb. nov. Circle: *Trichobryadybaena tuberculata* Wu & Guo, sp. nov.

but solid, with $5\frac{3}{4}$ – $6\frac{1}{2}$ (mean $6\frac{1}{8}$) whorls, embryonic shell with 2 – $2\frac{1}{4}$ (mean $2\frac{1}{8}$) whorls. Suture distinctly impressed, without a narrow edge. Umbilicus 4.28–5.55 mm (mean 4.94 mm) wide, ratio of umbilicus diameter to shell diameter 0.30–0.36 (mean 0.34). Columella arched. Columellar lip not distinctly dilated. Surfaces of adult and immature shells rough, spiral furrows and ribs absent. Shell surface evenly beset with hairs, hairs short and each hair knobbed and ciliated distally. Post-embryonic shell not granulose. Immature shells unkeeled. In mature shells body whorl unkeeled, whorls increasing more or less slowly. Body whorl slightly descending in front, base convex. Aperture rounded, oblique, 4.92–6.05 mm (mean 5.45 mm) in length, 4.68–5.70 mm (mean 5.15 mm) in width. Lips thin within. Basal lip minutely expanded. Peristome thin and not continuous. Parietal callus indistinct. Shell dull, uniformly in yellowish brown. Base of body whorl similarly colored.

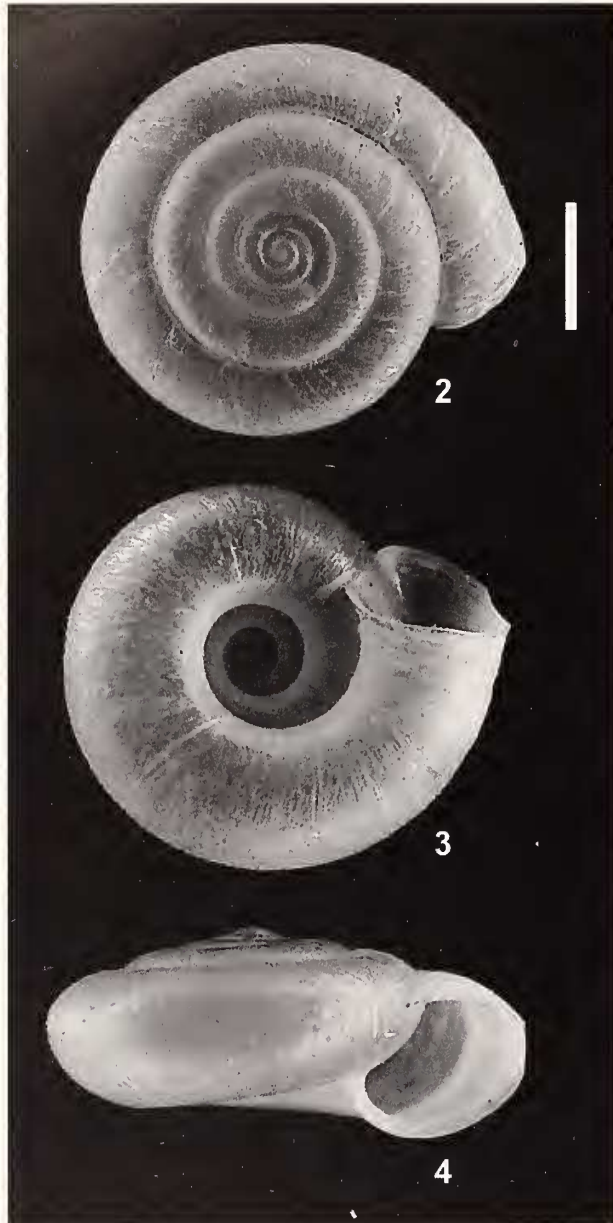
Measurements of holotype (ZMIZ00101-spec. 1):

Height 7.36 mm, diameter 15.37 mm, whorls six, embryonic shell two whorls, aperture length 5.85 mm, aperture width 5.70 mm, umbilicus diameter 5.47 mm.

Soft body color: Anteriorly with several brown spots.

Jaw: Arcuate with six to seven ribs dentating the concave margin. Ribs separate or contiguous.

Genitalia (Figures 5–10): Atrium short. Penis rather long, slender, with a simple penial caecum (SPC) near the penis-epiphallus transition (Figures 5, 7), SPC rather low. DVM present (Figures 5, 6, 9). Penis sheath (PS) approximately as long as DVM (Figures 5, 9). Wall of penis chamber with numerous thin and simple penis pilasters (PPs) (Figure 7). Retractor of moderate length. Dart sac of moderate size, more or less elongated. Accessory sac not found (Figures 6, 9). Amatorial dart about 2.8 mm long (in holotype), fairly straight, proximal part rounded (Figure 8). Ratio of bladed part to the whole dart about 0.5. In sagittal section, dart sac with V1 + V2, V3, V4



Figures 2–4. Figure 2. *Trichobrybaena chagangensis* Wu & Guo, sp. nov., shell of holotype (ZMIZ00101-sp1), apical view. Figure 3. *Trichobrybaena chagangensis* Wu & Guo, sp. nov., shell of holotype (ZMIZ00101-sp1), umbilical view. Figure 4. *Trichobrybaena chagangensis* Wu & Guo, sp. nov., shell of holotype (ZMIZ00101-sp1), apertural view. Scale bar = 5 mm.

structure, VI–4 closely situated. Chamber produced by V2 and V3 tiny and shallow, leading to mucus channel directly rather than to the dart sac chamber (DC). ADC absent (Figure 9). Mucus glands as long as dart sac, stalks indistinct. Lobules complicate and irregularly arborescent. Spermatheca oval. Free oviduct as long as vagina (Figure 5). Gonad glands palm-shaped, branched (Figure

10). In holotype (ZMIZ00101-spec. 1): dart sac 6.7 mm long, 2.0 mm wide; mucus duct 6.9 mm long; vagina 6.9 mm long; spermatheca duct 10.7 mm long; vas deferens 23.2 mm long; penis 27.0 mm long; penial retractor 4.6 mm long.

Material examined: Eighteen mature (ZMIZ00101-spec. 1–18) and 54 immature shells from Chagangxiang, Zhouqu County (33°48'N, 104°18'E), Gansu Province; 1650 m above sea level; coll. Chen De-niu & Zhang Guo-qing, 11 May 1998. Three animals dissected.

Types: Holotype (ZMIZ00101-spec. 1), Chagangxiang, Zhouqu County (33°48'N, 104°18'E), Gansu Province; 1650 m above sea level; coll. Chen De-niu & Zhang Guo-qing, 11 May 1998. Paratypes 17 (ZMIZ00101-spec. 2–18), the same data as holotype.

Distribution (Figure 1): Known only from the type locality, “Chagang,” Zhouqu County, Gansu Province.

Remarks: The shape of the present shell is similar to that of *Trichobrybaena submissa* (Deshayes), comb. nov. This species is easily distinguishable from its congeners by its unique hair structure, different shape of shell, and extremely long penis, which is about four times and about three times longer than that of *T. submissa* and *T. tuberculata*, sp. nov., respectively.

Etymology: The species is named after the type locality.

Ecology: Unknown for this species.

Trichobrybaena submissa (Deshayes, 1873)
comb. nov.

(Figures 1, 11–20)

Helix submissa, Deshayes, 1873:11, pl. II, figures. 30–32.

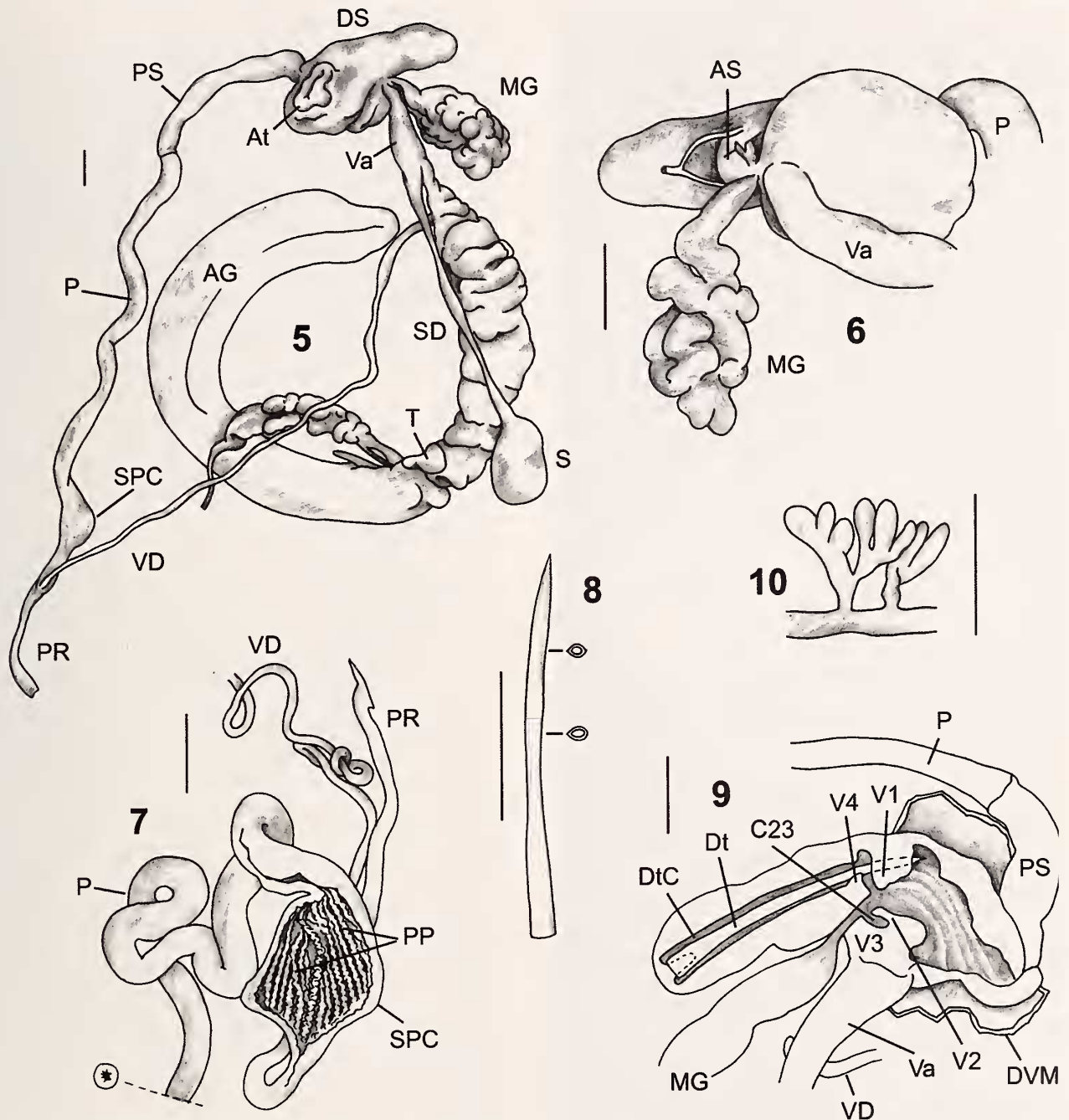
Helix submissa Desh., Heude, 1882: 30, pl. XIV, figures. 11, 11a. Möllendorff, 1884:337–338. Tryon, 1887:182, pl. 39, fig. 9, 10.

Trichochloritis submissa Deshayes, Pilsbry, 1895:124. Yen, 1939:129, Taf. 13, Fig. 29. Chen & Gao, 1987:113–114, fig. 145.

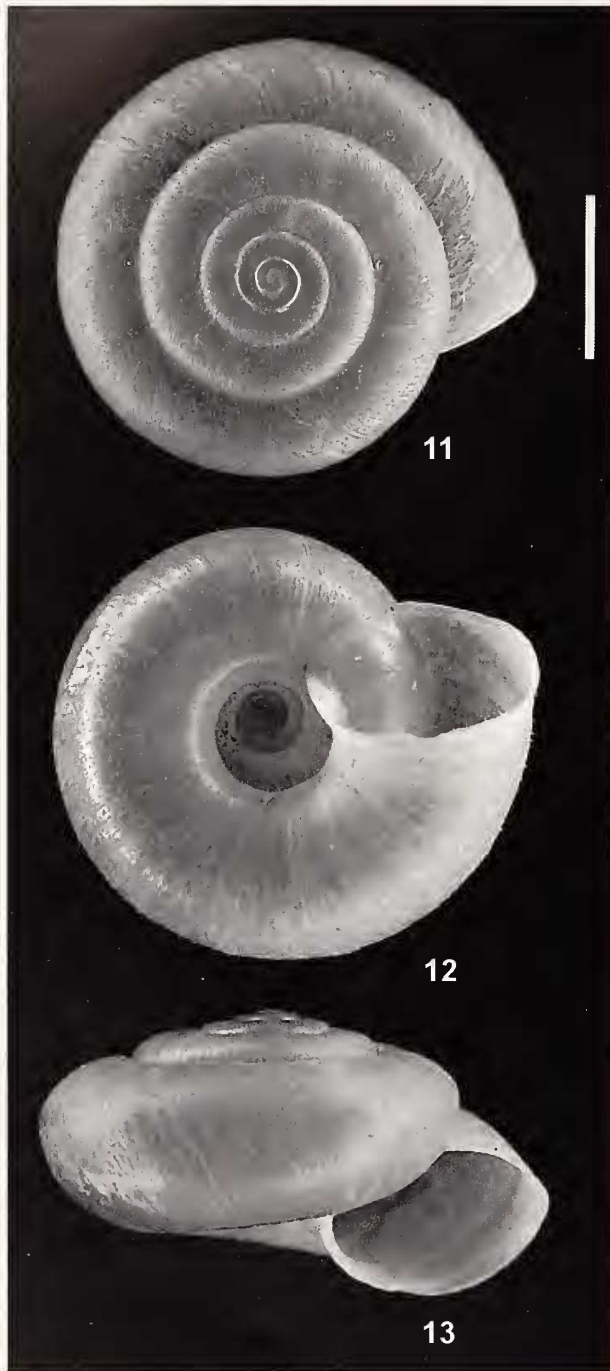
Plectotropis submissa (Desh.), Möllendorff. 1899:64.

Diagnosis: Shell rather thin. Suture deeply impressed. Whorls increasing rapidly. Aperture ovate. Lips seldom expanded. Soft body darkly spotted nearly throughout. Jaw with 9–10 ribs dentating the concave margin. Penis swollen and short. Amatorial dart about 4 mm long. VI–V4 closely situated, C23 deepened with entrance leading directly to DC, ADC extended distally. Chamber of accessory sac quite small. Mucus glands longer than dart sac, with stalks distinct. Duct of spermatheca short.

Shell (Figures 11–13): Height 5.92–8.22 mm (mean 6.93 mm) diameter 11.80–14.95 mm (mean 12.79 mm), ratio of height to diameter 0.49–0.59 (mean 0.54). Shell rather thin; apex distinct and somewhat blunt; with 5½–6 (mean



Figures 5–10. Figure 5. *Trichobryadybaena chagangensis* Wu & Guo, sp. nov., holotype (ZMIZ00101-sp1), general view of genitalia. Figure 6. *Trichobryadybaena chagangensis* Wu & Guo, sp. nov., holotype (ZMIZ00101-sp1), basal view of dart apparatus. Figure 7. *Trichobryadybaena chagangensis* Wu & Guo, sp. nov., holotype (ZMIZ00101-sp1), inside view of penis chamber. Figure 8. *Trichobryadybaena chagangensis* Wu & Guo, sp. nov., holotype (ZMIZ00101-sp1), dart with cross-sections. Figure 9. *Trichobryadybaena chagangensis* Wu & Guo, sp. nov., holotype (ZMIZ00101-sp1), sagittal section of dart apparatus. Figure 10. *Trichobryadybaena chagangensis* Wu & Guo, sp. nov., holotype (ZMIZ00101-sp1), two leaves of ovotestis. Scale bars = 1 mm.



Figures 11–13. Figure 11. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., ZMIZ00010-sp9, apical view. Figure 12. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., ZMIZ00010-sp9, umbilical view. Figure 13. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., ZMIZ00010-sp9, apertural view. Scale bar = 5 mm.

5½) whorls; embryonic shell with 1⅞–2¼ (mean 2⅞) whorls. Suture deep impressed, without a narrow edge. Umbilicus 2.70–3.70 mm (mean 3.18 mm) wide, ratio of umbilicus diameter to shell diameter 0.21–0.27 (mean 0.25). Columella arched. Columellar lip not dilated. Surface of adult and immature shells rough with short hairs. Embryonic shell finely granulose, and granulation radially arranged. Post-embryonic shell with tiny knobs bearing cuticle hairs, hairs with tapering tips. Immature shells unkeeled and unangulated. Body whorl of mature shells unkeeled. Whorls increasing rapidly. Body whorl large, somewhat descending in front, base convex. Aperture ovate, oblique, 4.73–6.66 mm (mean 5.59 mm) in length, 4.24–5.94 mm (mean 5.11 mm) in width. Lips thin within. Lips seldom expanded. Shell dull, uniformly in whitish corn-brown. Base of body whorl similarly colored.

Soft body color: Darkly spotted nearly throughout.

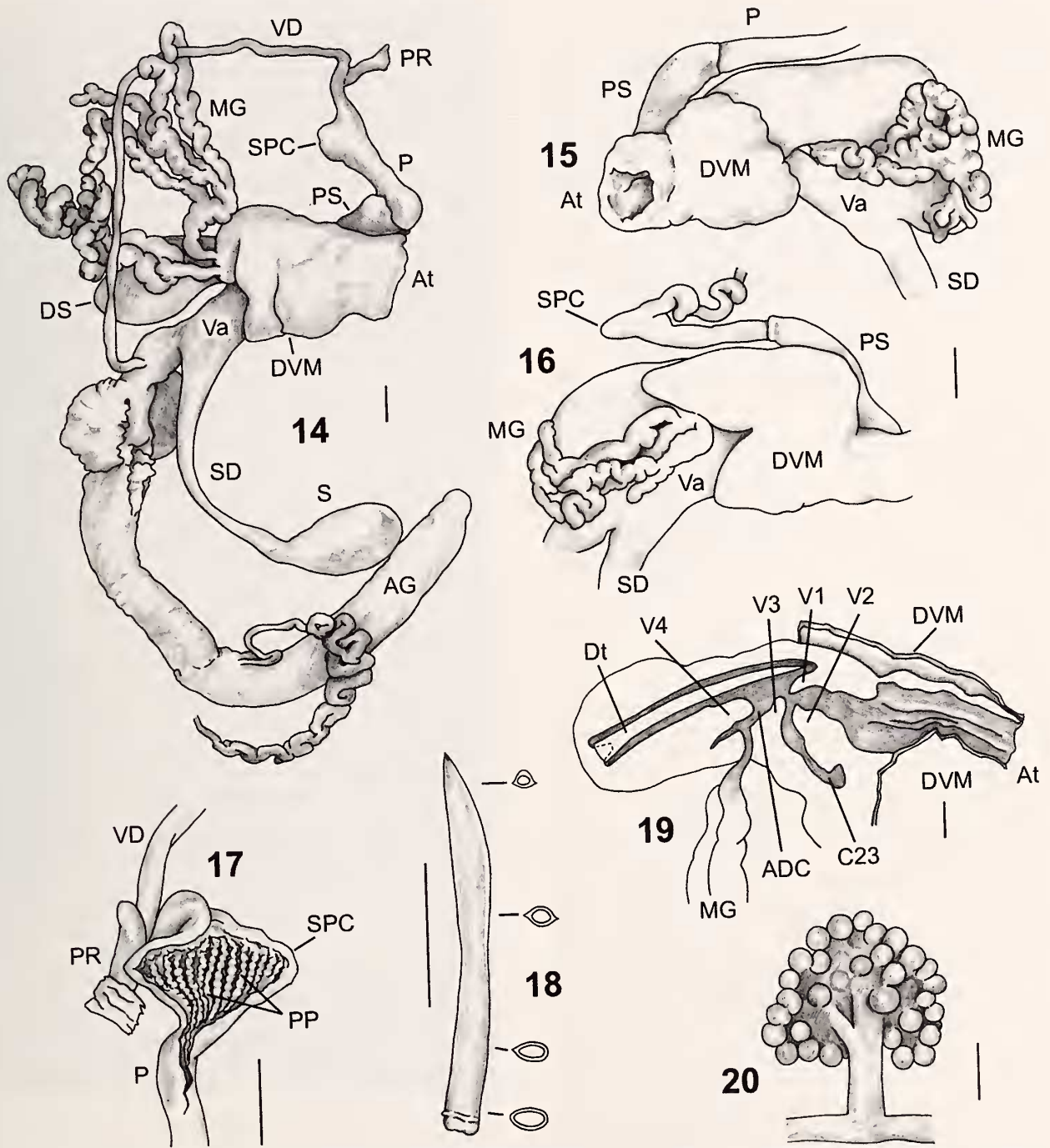
Jaw: Arcuate with about nine ribs dentating the concave margin. Ribs separate, narrow or wide.

Genitalia (Figures 14–20): Atrium short. Penis short and swollen (Figure 14), with a simple penial caecum (SPC) near the penis-epiphallus transition, SPC low (Figure 14). DVM present (Figures 14–16, 18). Penis sheath (PS) approximately as long as DVM (Figure 16). Wall of penis chamber simple, with numerous fine penis pilasters (PPs) (Figure 17). Retractor thick and short. Dart sac in moderate size, elongated; closely associated with the vagina. Amatorial dart about 3–4 mm long, proximal part distinctly expanded, tri-bladed at tip, medially two-bladed and proximally with an inner sharp blade (Figure 18). Ratio of bladed part to the whole dart length 0.60. In sagittal plane, dart sac with V1–V4, somewhat closely situated. Chamber produced by V2 and V3 rather deepened and directly leading to dart sac chamber (DC). Chamber of accessory sac quite small. ADC extended distally (Figure 19). Mucus glands longer than dart sac, stalk distinct. Lobules complicated and irregularly arborescent. Spermatheca somewhat elongatedly oval. Duct of spermatheca short. Gonad glands racemose (Figure 20). In one specimen (ZMIZ00010-spec. 1): dart sac 7.7 mm long, 1.6 mm wide; mucus duct 9.8 mm long; vagina 6.8 mm long; spermatheca duct 7.7 mm long; vas deferens 17.7 mm long; penis 7.3 mm long; penial retractor 1.5 mm long.

Material examined: Fifty-three immature, 20 mature individuals (ZMIZ00010-spec. 1–20) randomly selected from 87 mature shells were measured. All specimens from Hanzhong City (33°00'N, 107°00'E), Shaanxi Province; coll. Chen De-niu, 15 April 1992. Four animals dissected. Type material was not examined.

Remarks: Richardson (1983) did not list this species in his catalog of Bradybaenidae.

Ecology: The individuals of both juveniles and adults of



Figures 14–20. Figure 14. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., ZMIZ00010-sp1, general view of genitalia. Figure 15. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., ZMIZ00010-sp3, one side of dart apparatus. Figure 16. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., ZMIZ00010-sp3, another side of dart apparatus. Figure 17. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., ZMIZ00010-sp1, inside view of penis-chamber. Figure 18. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., dart with cross-sections, ZMIZ00010-sp22. Figure 19. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., ZMIZ00010-sp3, sagittal section of dart apparatus. Figure 20. *Trichobryadybaena submissa* (Deshayes, 1873) comb. nov., ZMIZ00010-sp1, a leaf of ovotestis. Figures 14–19 scale bars = 1 mm; Figure 20 scale bar = 0.5 mm.

this species aggregated under sandstone and broken bricks that are fairly dry in daylight. They are easily found in both fields and in residential areas near towns.

Distribution (Figure 1): Guizhou; Tibet; Sichuan: Luding, Tianquan, Baoxing (Type locality, in old spelling is "Mouping" or "Muping"), Fengjie, Guangyuan, between Guangyuan and Zhaohua; Chongqing; Gansu: between Guanting and Lijiapu; Anhui: Between Hukou and Dongliu; Shaanxi: Hanzhong.

Trichobradyaena tuberculata Wu & Guo, sp. nov.

(Figures 1, 21–29)

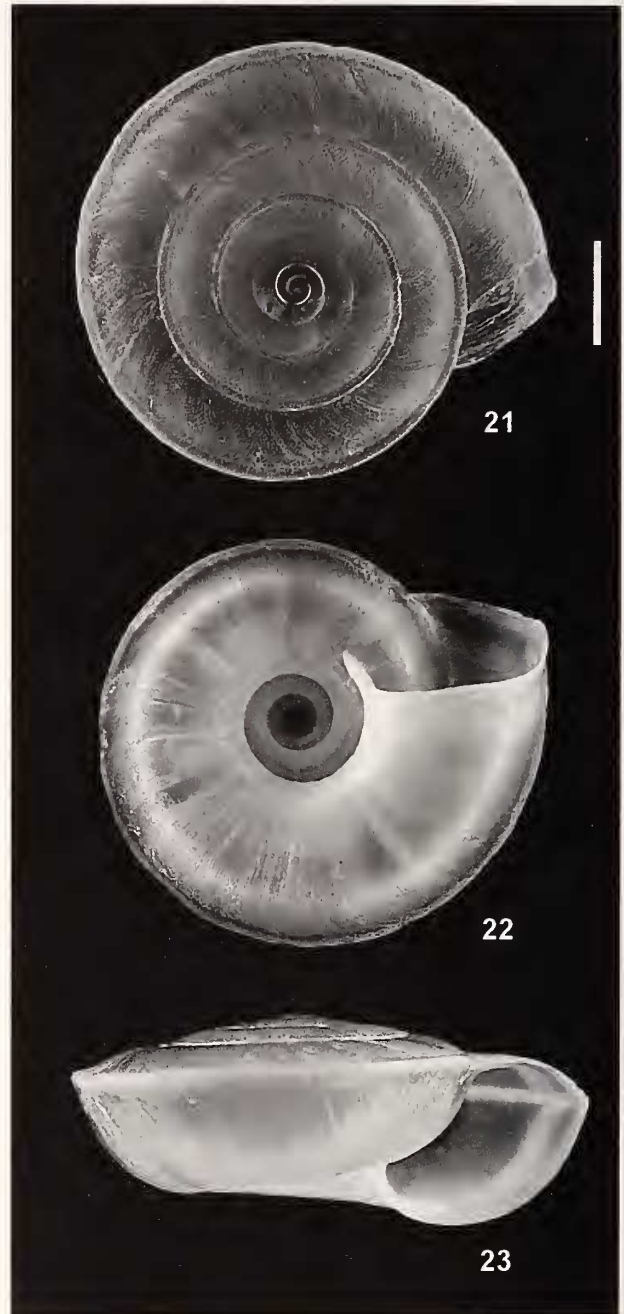
Diagnosis: Suture superficial, with a narrow edge above it. Umbilicus rather broad. Shell surface scaly. Post-embryonic shell granulose wholly. Immature shells keeled, body whorl keeled. Body whorl not descending, and base strongly convex. Aperture rhombic, more or less oblique. Lip thickened at basal part. Shell shiny. Base of body whorl in pale color, soft body darkened nearly throughout. Jaw with seven to eight ribs dentating the concave margin. Penis of moderate thickness. V1 far from V2–V4, C23 shallow with entrance leading directly to DC, ADC extended distally. Accessory sac of median size. Amatorial dart about 3.5 mm long. Mucus glands shorter than dart sac, lobules simply branched.

Shell (Figures 21–23): Height 6.81–9.34 mm (mean 8.12 mm), diameter 15.84–20.87 mm (mean 18.91 mm), ratio of height to diameter 0.38–0.49 (mean 0.43). Shell thin but solid; with $5\frac{1}{2}$ – $6\frac{1}{4}$ (mean $5\frac{7}{8}$) whorls; embryonic shell with 2 – $2\frac{1}{4}$ (mean 2^+) whorls; whorls convex. Suture superficial, with a narrow edge above it. Umbilicus 3.94–5.56 mm (mean 4.85 mm wide, ratio of umbilicus diameter to shell diameter 0.22–0.28 (mean 0.26). Columella arched. Columellar lip almost not dilated. Surface of adult and young shell hairless and rough with fairly fine scales. Post-embryonic shell evenly granulose throughout. Immature shells sharply keeled. Body whorl of mature shells sharply keeled, whorls increasing somewhat slowly. Body whorl not descending, with base strongly convex. Aperture roundly rhombic, oblique, 6.51–8.52 mm (mean 7.70 mm) in length, 5.65–8.13 mm (mean 7.15 mm) in width. Lips thickened on basal part. Outer lip and basal lip expanded. Shell slightly shiny, brown, carina white. Base of body whorl pale in color.

Measurements of holotype (ZMIZ00090-spec. 1): Height 8.12 mm, diameter 19.28 mm, whorl $5\frac{7}{8}$, embryonic shell $1\frac{3}{4}$ whorls, aperture length 7.62 mm, aperture width 7.25 mm, umbilicus diam. 4.74 mm.

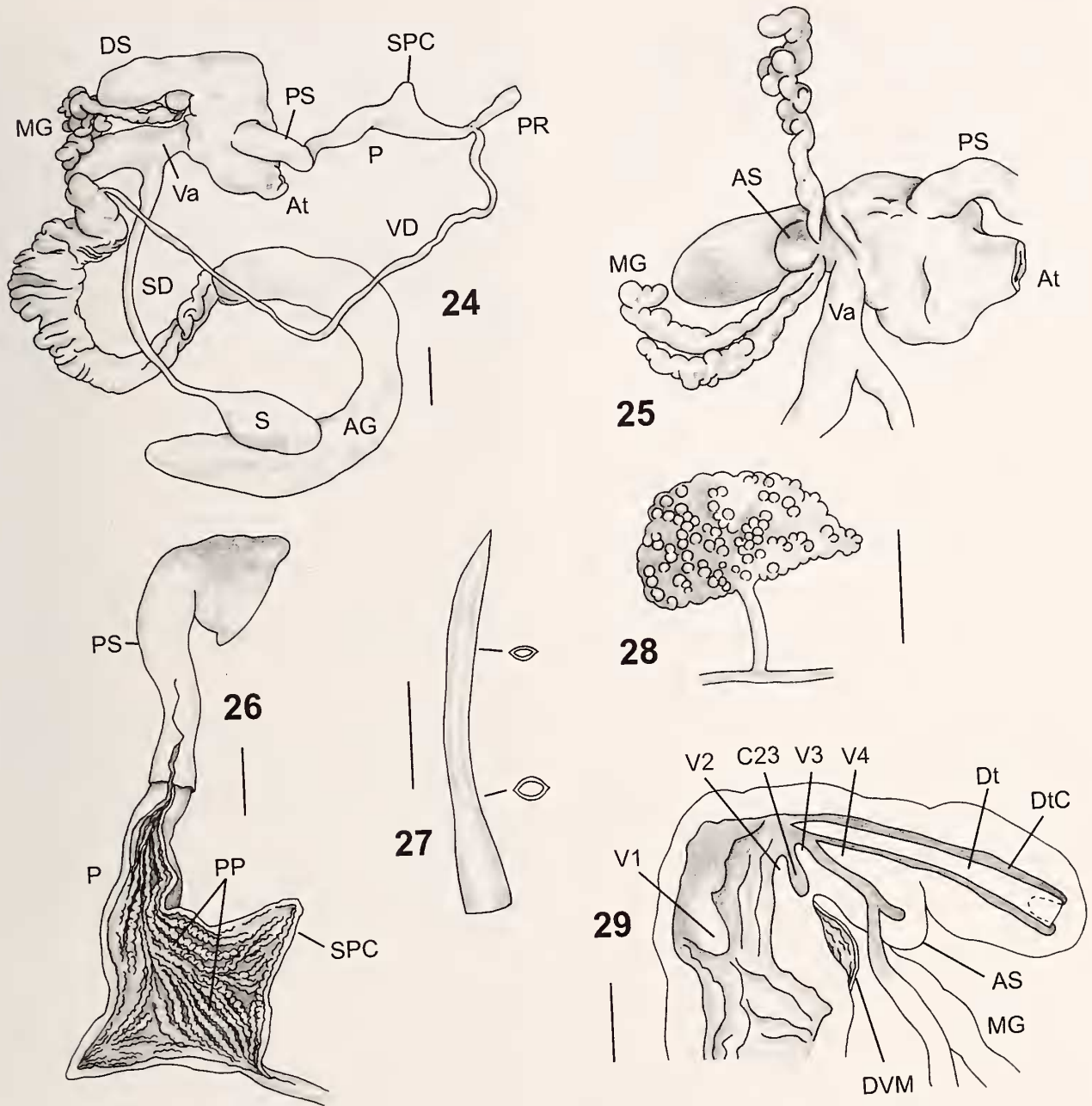
Soft body color: Nearly totally darkened.

Jaw: Arcuate with seven ribs dentating the concave margin.



Figures 21–23. Figure 21. *Trichobradyaena tuberculata* Wu & Guo, sp. nov., holotype (ZMIZ00090-sp1), apical view. Figure 22. *Trichobradyaena tuberculata* Wu & Guo, sp. nov., holotype (ZMIZ00090-sp1), umbilical view. Figure 23. *Trichobradyaena tuberculata* Wu & Guo, sp. nov., holotype (ZMIZ00090-sp1), apertural view. Scale bar = 5 mm.

Genitalia (Figures 24–29): Atrium short. Penis short and of moderate thickness (Figure 24), with a simple penial caecum (SPC) near the penis-epiphallus transition, SPC highly cone-shaped (Figures 24, 26). Inner wall of penis



Figures 24–29. Figure 24. *Trichobryadybaena tuberculata* Wu & Guo, sp. nov., holotype (ZMIZ00090-sp1), general view of genitalia. Figure 25. *Trichobryadybaena tuberculata* Wu & Guo, sp. nov., holotype (ZMIZ00090-sp1), dart apparatus, basal view. Figure 26. *Trichobryadybaena tuberculata* Wu & Guo, sp. nov., holotype (ZMIZ00090-sp1), inside view of penis chamber. Figure 27. *Trichobryadybaena tuberculata* Wu & Guo, sp. nov., paratype (ZMIZ00090-sp2), dart with cross-sections. Figure 28. *Trichobryadybaena tuberculata* Wu & Guo, sp. nov., paratype (ZMIZ00090-sp3), sagittal section of dart apparatus. Figure 29. *Trichobryadybaena tuberculata* Wu & Guo, sp. nov., holotype (ZMIZ00090-sp1), a leaf of ovotestis. Scale bars = 1 mm.

chamber with numerous thin and simple penis pilasters (PPs) (Figure 26). Retractor thick, somewhat short. Dart sac moderate in size, somewhat elongated. Amatorial dart about 3.5 mm long (in holotype), usually expanded prox-

imally (Figure 27). In sagittal plane, dart sac with V1–V4. V1 situated far from V2–V4, which are closely adjacent. Accessory sac–dart sac chamber (ADC) extended distally. C23 tiny, entrance of C23 leading directly to dart

sac chamber (DC) (Figure 28). Accessory sac of median size. Mucus glands shorter than dart sac, with stalks indistinct. Lobules simply branched. Spermatheca elongatedly ovate. Spermathecal duct of moderate length. Gonad glands racemose (Figure 29). In holotype (ZMIZ00090-spec. 1): dart sac 8.3 mm long, 1.8 mm wide; mucus duct 4.8 mm long; vagina 5.7 mm long; spermatheca duct 9.2 mm long; vas deferens 20.9 mm long; penis 9.3 mm long; penial retractor 2.1 mm long.

Material examined: Nineteen immature and 22 mature shells (ZMIZ00090-spec. 1~22) from Heishui, Jiuzai-gou County (33°12'N, 103°54'E), Sichuan Prov.; 1700 m above sea level; coll. Chen De-niu & Zhang Guo-qing, 18 May 1998. Four animals dissected.

Distribution (Figure 1): Known only from the type locality.

Types: Holotype (ZMIZ00090-spec. 1), Heishui, Jiuzai-gou County (Formerly Nanping County) (33°12'N, 103°54'E), Sichuan Prov.; 1700 m above sea level; coll. Chen De-niu & Zhang Guo-qing, 18 May 1998. Paratypes 21 (ZMIZ00090-spec. 2~22), the same data as holotype.

Remarks: This species shares the character of scaly or hairy shell and the genital configuration with its congeners. Besides different measurements, the sharper periphery distinguishes its shell from those of the other two species.

Etymology: The species obtains its name from the unique shape of its simple penial caecum.

Ecology: This species was found only in moist conditions in seasonal dry mixed forest. Specimens were congregated under stones scattered in such forest.

DISCUSSION

The type species of the new genus proposed in the present paper was previously considered to belong to *Plectotropis* Martens, 1860, by many authors, because of the flat shell associated with broad umbilicus, rough periostracum, and slowly increasing whorls. However, the absence of a flagellum differentiates it from *Plectotropis*. The genus can also be easily distinguished from *Trichocathaica* Gude, 1919, by the opposite coiling direction and its broader umbilicus. The presence of a simple penial caecum and two branches of mucus gland ducts and the absence of a flagellum differentiate it from all other bradybaenid genera. The unique simple penial caecum present in *Trichobradyaena*, gen. nov. is different from the tube-shaped caecum occurring in Genus A and Genus B (these two taxa will be published elsewhere and the difference will then be discussed in detail). It is noteworthy that the granulose status of the embryonic shell seems to be a significant character that is absolutely stable for every examined bradybaenid species, among about 110 Chinese

and some foreign bradybaenid species examined by the authors. The character-state of granulose or non-granulose embryonic shell is even useful in classification at the generic level in the Bradybaeninae (Yen, 1935). The distinct character of the gonad is employed for the description of bradybaenids for the first time. In the present new genus, the gonad leaf of two species shows a racemose form. The inner structure of the dart sac, which offers a series of quite stable characters among congeners, as indicated by Schileyko (1978) in some bradybaenids, is particularly scrutinized in the present work.

The simple penial caecum, which is expanded unilaterally and asymmetrically, can be immediately distinguished from the situation frequently occurring in *Bradybaena*. In the latter, the penis is symmetrically expanded near the transition to the epiphallus (H. Nordsieck, personal communication). Compared to the genus *Mastigeulota*, which is the only known bradybaenid genus that has a structure near the penis-epiphallus transition similar to that in *Trichobradyaena*, the new genus, can be distinguished by two mucus glands. Specimens collected from the type locality and other places suggest that *Mastigeulota* is a taxon without flagellum. While carrying out comparative work the authors found that there is a mistake in the description of genus *Mastigeulota* by Pilsbry (1895, p. 211, pl. 66, fig. 26) (also noticed by Nordsieck, 2002).

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